METHODS OF SAMPLING AND TESTING
MT 102-04
METHOD OF DETERMINING AIR CONTENT OF
FRESHLY MIXED CONCRETE BY THE PRESSURE METHOD
(Modified AASHTO T152)

1   Scope:

1.1   This method covers determination of the air content of freshly mixed concrete from observation of the change in volume of concrete with a change in pressure.

1.2   This method is intended for use with concretes and mortars made with relatively dense aggregates. It is not applicable to concretes made with lightweight aggregates, air-cooled blast-furnace slag, or aggregates of high porosity.

2   Reference Document:

2.1   *AASHTO:*
        T121 Mass per Cubic Meter (Cubic Foot), Yield, and Air Content (Gravimetric) of Concrete
        T152 Air Content of Freshly Mixed Concrete by the Pressure Method

        MT. Materials Manual:
        MT-105 Sampling Freshly Mixed Concrete

3   Apparatus:

3.1   *Air Meter* - There are two basic operational designs available employing the principle of Boyle's law. For purposes of reference, these will be designated Type A Meter and Type B Meter.

3.1.1   *Type A Meter* - An air meter consisting of a measuring bowl and cover assembly (see Figure 1) conforming to the requirements of Sections 3.2 and 3.3. The operational principle of this meter consists of introducing water to a predetermined height above a sample of concrete of known volume, and the application of a predetermined air pressure over the water. The determination consists of the reduction in volume of the air in the concrete sample by observing the amount the water level is lowered under the applied pressure, the latter amount being calibrated in terms of percent of air in the concrete sample.

3.1.2   *Type B Meter* - An air meter consisting of a measuring bowl and cover assembly (see Figure 2) conforming to the requirements of Section 3.2 and 3.3. The operational principle of this meter consists of equalizing a known volume of air at a known pressure in a sealed air chamber with the unknown volume of air in the concrete sample, the dial on the pressure gage being calibrated in terms of percent air for the observed pressure at which equalization takes place. Working pressures of 7.5 to 30.0 psi (51 to 207 kPa) having been used satisfactorily.

3.2   *Measuring Bowl* - The measuring bowl must be essentially cylindrical in shape, made of steel, hard metal, or other hard material not readily attacked by the cement paste, having a minimum diameter equal to 0.75 to 1.25 times the height, and a capacity of at least 0.20 ft³ (0.006 m³). It must be flanged or otherwise constructed to provide for a pressure tight fit between the bowl and cover assembly. The interior surfaces of the bowl and surfaces of rims, flanges and other component fitted parts must be machined smooth. The measuring bowl and cover assembly must be sufficiently rigid to limit expansion of the apparatus assembly to not more than 0.1 percent of air content on the indicator scale when under normal operating pressure.

3   Apparatus: (continued)

3.3   Cover Assembly:

3.3.1   The cover assembly shall be made of steel or other hard metal not readily attacked by the cement paste. It must be flanged or otherwise constructed to provide for a pressure-tight fit between bowl and cover assembly and must have machined smooth interior surfaces contoured to provide an air space above the level of the top of the measuring bowl. The cover must be sufficiently rigid to limit the expansion factor of the apparatus assembly as prescribed in 3.2.

3.3.2   The cover assembly must be fitted with a means for direct reading of the air content. The cover for the Type A meter must be fitted with a standpipe, which may be a transparent graduated tube or may be a metal tube of uniform bore with a glass water gage attached. In the Type B meter, the dial of the pressure gage must be calibrated to indicate the percent of air. Graduations must be provided for a range in air content of at least 8 percent easily readable to 0.1 percent as determined by the proper air pressure calibration test.

3.3.3   The cover assembly shall be fitted with air valves, air bleeder valves, and petcocks for bleeding off or through which water may be introduced as necessary for the particular meter design. Suitable means for clamping the cover to the bowl shall be provided to make a pressure-tight seal without entrapping air at the joint between the flanges of the cover and bowl. A suitable hand pump shall be provided with the cover either as an attachment or as an accessory.

3.4   *Calibration Vessel* - A measure having an internal volume equal to a percent of the volume of the measuring bowl corresponding to the approximate percent of air in the concrete to be tested; or, if smaller, it shall be possible to check calibration of the meter indicator at the approximate percent of air in the concrete to be tested by repeated filling of the measure. When the design of the meter requires placing the calibration vessel within the measuring bowl to check calibration, the measure shall be cylindrical in shape and of an inside depth 1/2 in. (13 mm) less than that of the bowl. A satisfactory measure of this type may be machined from No. 16 gage brass tubing, of a diameter to provide the volume desired, to which a brass disk 1/2 in. in thickness is soldered to form an end. When design of the meter requires withdrawing of water from the water-filled bowl and cover assembly to check calibration, the measure may be an integral part of the cover assembly or may be a separate cylindrical measure similar to the above described cylinder.

3.5   The designs of various available types of airmeters are such that they differ in operating techniques and therefore, all of the items described in 3.6 through 3.14 may not be required. The items required must be those necessary for use with the particular design of apparatus used to satisfactorily determine air content in accordance with the procedures prescribed herein.

3.6   *Spray Tube* - A brass tube of appropriate diameter, which may be an integral part of the cover assembly or which may be provided separately. It must be so constructed that when water is added to the container, it is sprayed to the walls of the cover in such a manner as to flow down the sides causing a minimum of disturbance to the concrete.

3.7   *Trowel* **-** A standard brick mason's trowel.

3.8   *Tamping Rod* - The tamping rod shall be a round, straight steel rod 5/8 in. (16 mm) in diameter and approximately 24 in. (600 mm) in length, having the tamping end rounded to a hemispherical tip the diameter of which is 5/8 in.

3.9   *Mallet* - A mallet (with a rubber or rawhide head) weighing approximately 1.25 ± 0.50 lb. (0.57 ± 0.23 kg) for use with measures of 0.5 ft.³ (14 dm³) or smaller, and a mallet weighing approximately 2.25 ± 0.50 lb. (1.02 ± 0.23 kg) for use with measures larger than 0.5 ft.³.

3.10   *Strike-Off Bar* - A flat straight bar of steel or other suitable metal at least 1/8 in. (3 mm) thick and 3/4 in. (20 mm) wide by 12 in. (300 mm) long.

3   Apparatus: (continued)

3.11   *Funnel* - with the spout fitting into spray tube.

3.12   *Measure of Water* - having the necessary capacity to fill the indicator with water from the top of the concrete to the zero mark.

4   Calibration of Apparatus:

4.1   Calibration of the apparatus must be performed at the job site before air content determinations are made. The check cylinder and air meter must have the same number. Since the volumes of the air meters vary slightly, the meters must be individually calibrated and only their corresponding check cylinders may be used for this purpose. The calibration process is as follows:

4.1.1   Place the brass check cylinder in the dry air meter bowl with the open end down.

4.1.2.   Fill the bowl with water and clamp on the top of the air meter.

4.1.3   Fill the assembled apparatus with water to the zero mark.

4.1.4   Close remaining valves and apply air pressure until the scale reading on the water glass gauge reads the same as the air content marked on the brass check cylinder.

4.1.5   Tap sides of the bowl and cover lightly with the mallet to remove any entrapped air and to relieve any local restraints.

4.1.6   Check the level of the water in the glass to see if it remains the same as the brass check cylinder and if so, record the air pressure.

4.1.7   Gradually release the air pressure by opening the funnel valve on top of the air meter cover and check if water level returns to the zero mark.

4.1.8   Repeat steps 4.1.4 through 4.1.7. If the water level returns to the same reading as before, record the psi on a piece of masking tape and place the tape on the air gauge glass.

4.1.9   If the water level fails to return within 0.05 percent of the zero mark, a check should be made to determine where leakage has occurred.

4.1.10 After leakage has been corrected, the entire calibration must be repeated.

5   Determination of Aggregate Correction Factor:

5.1   *Procedure* – Determine the aggregate correction factor on a combined sample of fine and coarse aggregate as directed in sections 6.2 to 6.4. It is determined independently by applying the calibrated pressure to a sample of inundated fine and coarse aggregate in approximately the same moisture condition, amount, and proportions occurring in the concrete sample under test.

5.2   *Aggregate Sample Size* – Calculate the weights of fine and coarse aggregate present in the sample of fresh concrete whose air content is to be determined, as follows:

$F_s = (S/B) \times F_b$

$C_s = (S/B) \times C_b$

where:

F_s = weight of fine aggregate in concrete sample under test, lb (kg);

5 **Determination of Aggregate Correction Factor:** (continued)

S = volume of concrete sample (same as volume of measuring bowl), ft^3 (m^3);

B = volume of concrete produced per batch (Note 2), ft^3 (m^3);

F_b = total weight of fine aggregate in the moisture condition used in batch, lb (kg);

C_s = weight of coarse aggregate in concrete sample under test, lb (kg), and

C_b = total weight of coarse aggregate in the moisture condition used in batch, lb (kg).

Note 2 – The volume of concrete produced per batch can be determined in accordance with applicable portions of T 121.

Note 3 – The term "weight" is temporarily used in this standard because of established trade usage. The word is used to mean both "force☺" and "mass" and care must be taken to determine which is meant in each case (SI unit for force = Newton and for mass = kilogram).

5.3 *Placement of Aggregate in Measuring Bowl* – Mix representative samples of fine aggregate F_s, and coarse aggregate C_s, and place in the measuring bowl filled one-third full with water. Place the mixed aggregate, a small amount at a time, into the measuring bowl; if necessary, add additional water so as to inundate all of the aggregate. Add each scoopful in a manner that will entrap as little air as possible and remove accumulations of foam promptly. Tap the sides of the bowl and lightly rod the upper 1 in. (25 mm) of the aggregate about 8 – 12 times. Stir after each addition of aggregate to eliminate entrapped air.

5.4 *Aggregate Correction Factor Determination:*

5.4.1 *Initial procedure for Types A and B Meters* – When all of the aggregate has been placed in the measuring bowl, remove excess foam and keep the aggregate inundated for a period of time approximately equal to the time between introduction of the water into the mixer and the time of performing the test for air content before proceeding with the determination as directed in section 5.4.2 and 5.4.3.

5.4.2 *Type A Meter* – Complete the test as described in Sections 7.2.1 and Note 1. The aggregate correction factor, G, is equal to $h_1 - h_2$. (See Figure 1)(Note 4)

5.4.3 *Type B Meter* – Perform the procedures as described in section 7.3.1. Remove a volume of water from the assembled and filled apparatus approximately equivalent to the volume of air that would be contained in a typical concrete sample of a size equal to the volume of the bowl. Complete the test as described in Section 7.3.2. The aggregate correction factor, G, is equal to the reading on the air-content scale minus the volume of water removed from the bowl expressed as a percent of the volume of the bowl. (See Figure 1)

Note 4 – The aggregate correction factor will vary with different aggregates. It can be determined only by test, since apparently it is not directly related to absorption of the particles. The test can be easily made and must not be ignored. Ordinarily the factor will remain reasonably constant for given aggregates, but an occasional check test is recommended.

6 **Preparation of Concrete Test Sample:**

6.1 Obtain the sample of freshly mixed concrete in accordance with applicable procedures of Method MT-105.

7   Procedure for Determining Air Content of Concrete:

7.1   Placement and Consolidation of Sample:

7.1.1   Dampen the interior of the measuring bowl and place it on a flat, level, firm surface. Place a representative sample of the concrete, prepared as described in section 5, in the measuring bowl in equal layers. Consolidate each layer by the rodding procedure (6.1.2). Strike off the final consolidated layer (6.1.3).

7.1.2   *Rodding* - Place the concrete in the measuring bowl in three layers of approximately equal volume. Consolidate each layer of concrete by 25 strokes of the tamping rod evenly distributed over the cross section. After each layer is rodded, tap the sides of the measure smartly 10 to 15 times with the mallet to close any voids left by the tamping rod and to release any large bubbles of air that may have been trapped. Rod the bottom layer throughout its depth, but the rod shall not forcibly strike the bottom of the measure. In rodding the second and final layers, use only enough force to cause the rod to penetrate the surface of the previous layer about 1 in. (25 mm). Add the final layer of concrete in a manner to avoid excessive overfilling (7.1.3).

7.1.3   *Strike-Off* - After consolidation of the concrete, strike off the top surface by sliding the strike-off bar across the top flange or rim of the measuring bowl with a sawing motion until the bowl is just level full. On completion of consolidation, the bowl must not contain a great excess or deficiency of concrete. Removal of approximately 1/8 in. (3 mm) during strike off is optimum. A small quantity of representative concrete may be added to correct a deficiency. If the measure contains a great excess, remove a representative portion of concrete with a trowel or scoop before the measure is struck off.

7.2   Procedure - Type A Meter:

7.2.1   *Preparation for Test* - Thoroughly clean the flanges or rims of the bowl and of the cover assembly so that when the cover is clamped in place a pressure-tight seal will be obtained. Assemble the apparatus and add water over the concrete by means of the tube until it rises about the halfway mark in the standpipe. Incline the apparatus assembly about 30 degrees from vertical and, using the bottom of the bowl as a pivot, describe several complete circles with the upper end of the column, simultaneously tapping the cover lightly to remove any entrapped air bubbles above the concrete sample. Return the apparatus assembly to a vertical position and fill the water column slightly above the zero mark, while lightly tapping the sides of the bowl. Bring the water level to the zero mark of the graduated tube before closing the vent at the top of the water column.

Note 1 - *The internal surface of the cover assembly should be kept clean and free from oil or grease; the surface should be wet to prevent adherence of air bubbles that might be difficult to dislodge after assembly of the apparatus.*

7.2.2   *Test Procedure* - Apply slightly more than the desired test pressure, P, (about 0.2 psi) (1,380 Pa more, as described in 4.1.4) to the concrete by means of the small hand pump. To relieve local restraints, tap the sides of the measure sharply and, when the pressure gage indicates the exact test pressure, as described in 4.1.6, read the water level, h_1, and record to the nearest division or half-division on the graduated precision-bore tube or gage glass of the standpipe. The value is the percentage of air in the concrete. For extremely harsh mixes it may be necessary to tap the bowl vigorously until further tapping produces no change in the indicated air content. Gradually release the air pressure through the vent at the top of the water column and tap the sides of the bowl lightly for about one min. Record the water level, h_2, to the nearest division or half division. Calculate the apparent air content as follows:

$$A_1 = h_1 - h_2$$

7.2   Procedure - Type A Meter: (continued)

where:

A_1 =   apparent air content.

h_1 =   water level reading at pressure, P.

h_2 =   water level reading at zero pressure after release of Pressure, P.

7.2.3   *Check Test* - Repeat the steps described in 7.2.2 without adding water to reestablish the water level at the zero mark. The two consecutive determinations of apparent air content should check within 0.2% of air and shall be averaged to give the value of air in the concrete as a percentage.

7.3   Procedure - Type B Meter:

7.3.1   *Preparation for Test* - Thoroughly clean the flanges or rims of the bowl and the cover assembly so that when the cover is clamped in place a pressure tight seal will be obtained. Assemble the apparatus. Close the air valve between the air chamber and measuring bowl and open both petcocks on the holes through the cover. Using a rubber syringe, inject water through one petcock until water emerges from the opposite petcock. Jar the meter gently until all air is expelled from the same petcock.

7.3.2   *Test Procedure* - Close the air bleeder valve on the chamber and pump air into the air chamber until the gage hand is on the initial pressure line. Allow a few seconds for the compressed air to cool to normal temperature. Stabilize the gage hand at the initial pressure line by pumping or bleeding-off air as necessary, tapping the gage lightly by hand. Close both petcocks on the holes through the cover. Open the air valve between the air chamber and the measuring bowl. Tap the side of the measuring bowl smartly with the mallet to relieve local restraints. Lightly tap the pressure gage by hand to stabilize the gage hand and read the percentage of air on the dial of the pressure gage. Failure to close the main valve before releasing the pressure from either the container or the air chamber will result in water being drawn into the air chamber, thus introducing error in subsequent measurements. In the event water enters the air chamber, it must be bled from the air chamber through the bleeder valve followed by strokes of the pump to blow out the last traces of water. Release the pressure by opening both petcocks before removing the cover.

8   Calculation:

8.1   *Air Content of Sample Tested* – Calculate the air content of the concrete in the measuring bowl as follows:

$$A_s = A_1 - G$$

where:

As = air content of sample tested, percent;

$A1$ = apparent air content of the sample tested, percent (Section 7.2.2 and 7.2.3); and

G = aggregate correction factor, percent (Section 5).

9   Simple Maintenance:

9.1   Air meters must be kept clean to give accurate readings.

9.1.1   Thoroughly clean and dry equipment after each use. Never clamp and store meter while bowl is still damp.

9   **Simple Maintenance:** (continued)

9.1.2   Occasionally clean and oil threads in the funnel valve. It is extremely important that threads on the hold down clamps be cleaned and oiled at all times.

9.1.3   Never strike the surface of the bowl where the gasket rests.

9.1.4   Occasionally oil the petcocks and clean openings with a fine wire.

9.1.5   Clean the water glass occasionally. This can be done by removing the valve from the funnel and using the brush, which is included for that purpose.

9.1.6   To prevent sticking and destroying the rubber gasket, a piece of waxed paper should be placed between the bowl and cover when the apparatus is stored.
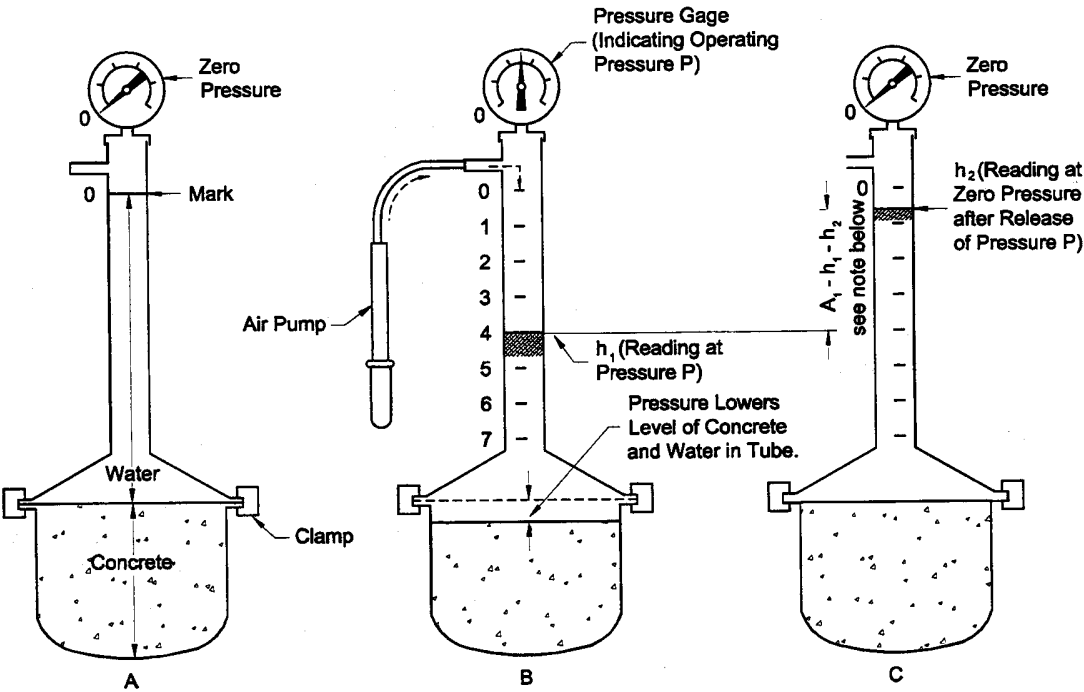
Note: $A_1 = h_1 - h_2$ when bowl contains concrete as shown in this figure; when bowl contains only aggregate and water, $h_1 - h_2 = G$ (aggregate correction factor.)
$A_1 - G = A$ (entrained air content of concrete).

Figure 1—Illustration of the Pressure Method for Air Content—Type A Meter
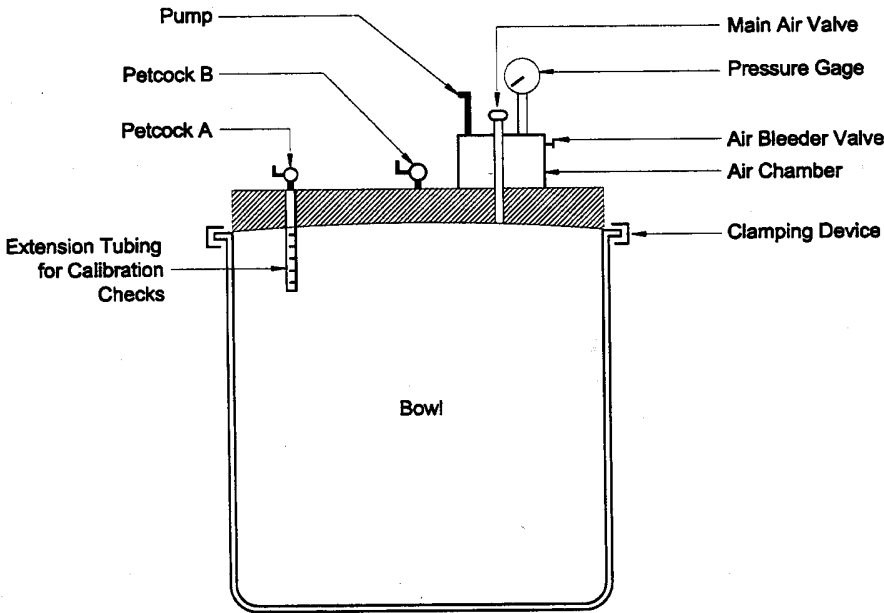
Figure 2—Schematic Diagram—Type B Meter